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A Comparison of Measured Relative Transmission Loss with Model Predicted Transmission Loss in the Straits of Sicily

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ABSTRACT

A comparison of a measured data set with five different model predictions is presented. Three of the predictions use the Low Frequency Bottom Loss model for the area, one prediction uses a geoacoustic model, and one (pure cylindrical spreading) assumes no bottom loss. All five predictions agree with the measured data well, with root-mean-square error under 2.5 dB. The models using bottom loss follow the trend better than cylindrical spreading.

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A COMPARISON OF MEASURED RELATIVE TRANSMISSION LOSS WITH MODEL PREDICTED TRANSMISSION LOSS IN THE STRAITS OF SICILY

INTRODUCTION

The purpose of this technical note is to report the results of comparing transmission loss predictions from a number of models using the Navy standard Low Frequency Bottom Loss Model (LFBL) with a prediction made using a geoacoustic based model of bottom loss against a measured data set. The transmission loss data used for the comparisons was taken by the Naval Air Warfare Center Aircraft Division (NAWCAD) in the Straits of Sicily as part of the ASW Environmental Acoustic Support (AEAS) harsh environment program. The data consists of relative transmission loss (relative to the loss at 2 nmi) along a single radial.

DATA DESCRIPTION

The acoustic and environmental used (with the exception of the geoacoustic information) in this study was collected, or assembled by NAWCAD (1992) as part of the AEAS harsh environment program. The acoustic data was reported as relative transmission loss; thus, the shape of the relevant environmental parameters will be paramount rather than the absolute values. The reduced data was then simulated by NAWCAD using the Navy standard passive Raymode model (Leiberger, 1971), and the NAWCAD Bistatic Active Model (BAM) as described by Bartberger (1991).

The data was collected using 60 ft denotation depth Mark 64 SUS charges as sources and padded AN/SSQ 57 omnidirectional sonobuoys deployed at 400 ft as receivers, the frequency band used spanned 175 to 625 Hz. The receiver were spaced every 2 nmi along an east-west track beginning at approximately 34° 55' North by 14° 27' East.

The environment was assumed to be range-independent (Fig. 1 shows the measured sound speed profile down to the assumed depth of the water sediment interface), with the bottom loss described using LFBL as indicated in Figure 2. Examination of the sound speed profile reveals that it is virtually isovelocity, with a variation of 7 ft/s over 1200 ft. The source (at 60 ft depth) has a sound velocity 4 ft/s less that is observed by the receiver, which is at the sound speed maxima. The small difference gives rise to a weak surface duct; thus, surface duct propagation should be unimportant in the predictions.

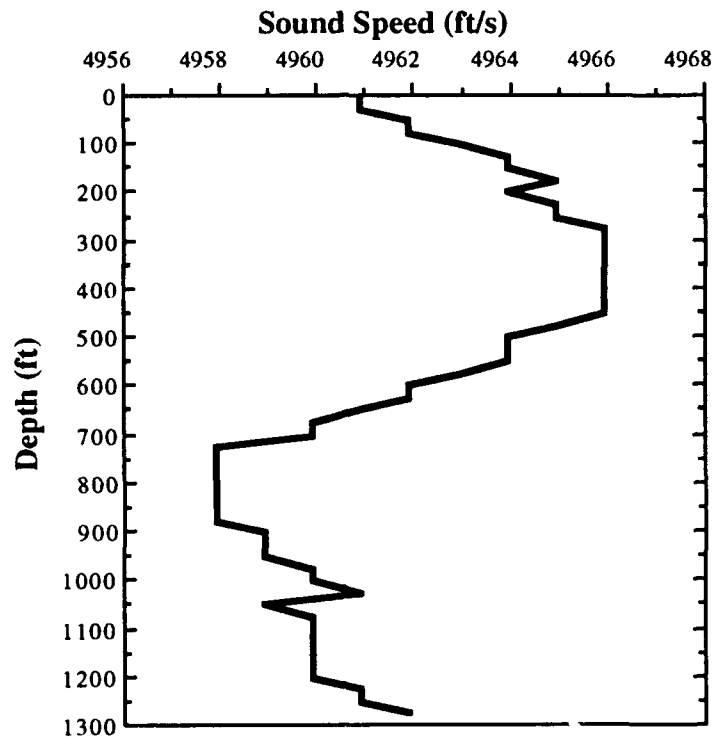


Figure 1. Plot of measured sound speed versus depth.

The transmission loss data for the frequency band 175 to 625 Hz (relative to the loss at 2-nmi range) is illustrated in Figure 3 where the transmission loss for cylindrical spreading has been added for reference. The measured transmission loss shows two features that depart from that expected from a range-independent area. First the relative loss is lower than expected at 4-nmi range, and there is a suggestion of structure at approximately 12-nmi range. The two deviations away from cylindrical spreading can be explained by the bathymetry illustrated in Figure 4. Initially the propagation is downslope, which causes the bottom bounce energy to arrive at the receiver depth at longer ranges than the flat bottom case, then the bottom slopes up, which causes a second (or later) bottom bounce to arrive at shorter ranges than would be expected.

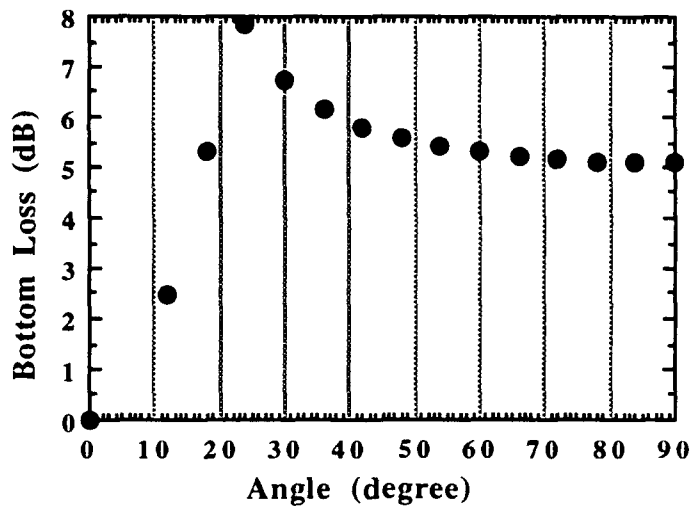


Figure 2. Scatter plot of bottom loss versus grazing angle (derived from LFBL) for the measurement area.

Despite the difference between the modeled bathymetry and the actual bathymetry, it should be noted that the cylindrical spreading model prediction has root-mean-square error of 1.6 dB relative to the measured data (if the data at 2 nmi is included). This suggests that the propagation models using range-independent environments should do reasonably well.

That is, the dominate energy paths suffer little loss through interaction with the bottom. Examination of the sound speed profile suggests that paths that interact with the receiver (at the global sound speed maximum at 400 ft) will interact with the bottom, thus bottom interaction must be considered. The bottom loss curve presented in Figure 2 suggests that there is a small region where bottom interaction can occur with low bottom loss.

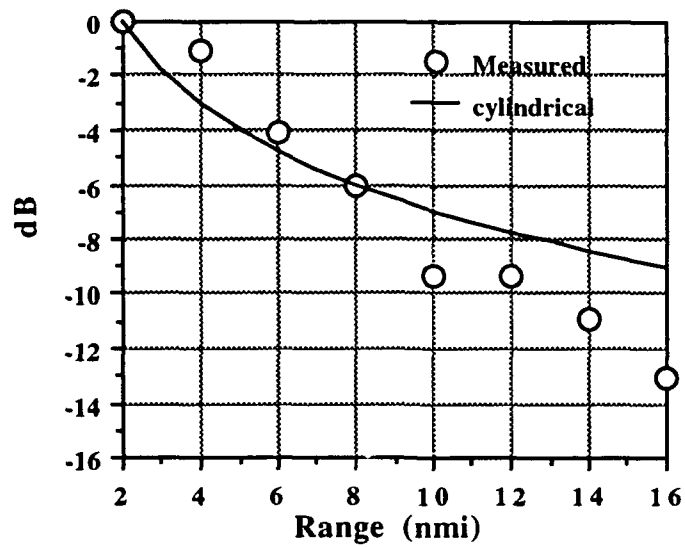


Figure 3. Comparison plot of measured transmission loss (relative to 2 nmi) versus range and cylindrical spreading.

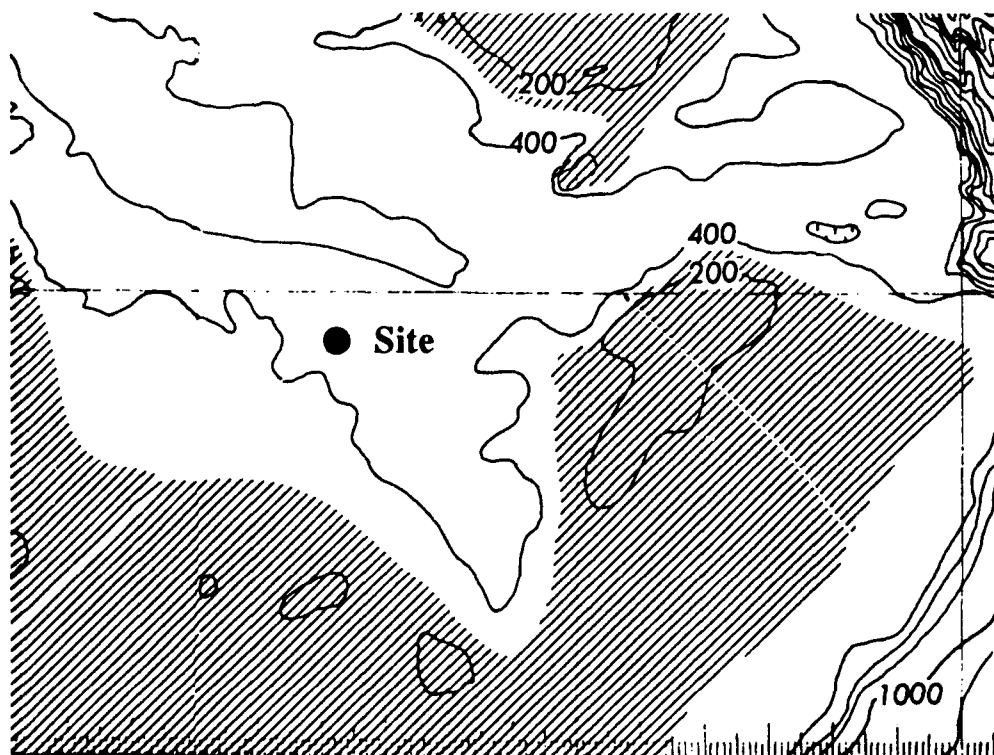


Figure 4. Schematic map of the exercise area.

GEOACOUSTIC MODEL

For comparison with the bottom loss indicated by LFBL a geoacoustic model of the sedimentary material generated by Matthews (1982) has been converted to bottom loss versus grazing angle table using the Reflec model, a Naval Research Laboratory program based on the Thompson-Haskill matrix approach (Brekhovishikh, 1960). Table 1 lists the geoacoustic model, and Figure 5 shows a comparison of the geoacoustic generated bottom loss with LFBL generated bottom loss. Although an insufficient sample of the LFBL curve is presented, the structure of the low grazing angle part of the bottom loss curves is similar, and suggests that the predicted transmission loss will be similar.

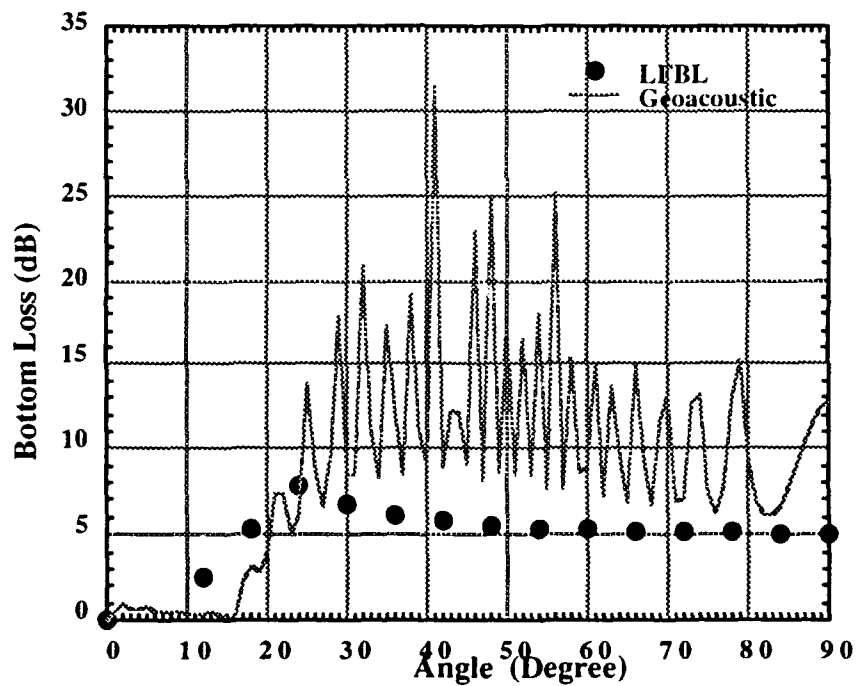


Figure 5. Plot showing comparison of geoacoustic model generated bottom loss curve versus LFBL generated bottom loss curve.

Table 1. Geoacoustic model of the Straits of Sicily (Matthews, 1982).

Depth (meters)	Compression speed (m/s)	Shear speed (m/s)	Compression attenuation dB/m/kHz	Shear attenuation dB/m/kHz	Density (g/cc)
0	1502	116	.0045	15.0	1.52
25	1534	232	.0060	20.0	1.55
75	1552	301	.0075	25.0	1.57
50	1596	333	.0090	30.0	1.62
100	1625	365	.0110	36.7	1.65
125	1653	395	.0120	40.0	1.69
150	1680	409	.0130	43.3	1.72
175	1706	424	.0140	46.7	1.75
200	1731	438	.0150	50.0	1.78
250	1778	467	.0170	56.7	1.83
300	1820	495	.0190	63.3	1.88
350	1857	525	.0195	65.0	1.92
400	1889	554	.0190	65.3	1.95
500	1937	612	.0160	53.3	2.01

RESULTS OF MODELING

Figure 6 shows a plot of the measured data and predicted results from cylindrical spreading without absorption loss, Raymode, BAM, ADAM using LFBL based bottom loss, and ADAM using a geoacoustic based bottom loss. For each model the transmission loss has been set to 0 at 2 nmi; thus, the comparisons are of relative transmission loss. Interpretation of the plot suggest that each of the models performs adequately, the differences between the models and the data seem to be largely caused by unresolved bathymetric effects. The comparisons further show, in relative terms, that LFBL and geoacoustic based bottom loss curves give rise to similar transmission loss curves.

Table 2 lists the values used in producing Figure 6. Note that the root-mean-square value of the absolute error is less than 2.5 dB for each of the models. Given the few data points available for this comparison, it is not possible to conclude that one model is better than another, nor that the geoacoustic model is better than LFBL in this area for transmission loss. It should be noted that while cylindrical spreading predicts the data well from a statistical point of view, the models using bottom loss present results that follow the trend of the data more precisely.

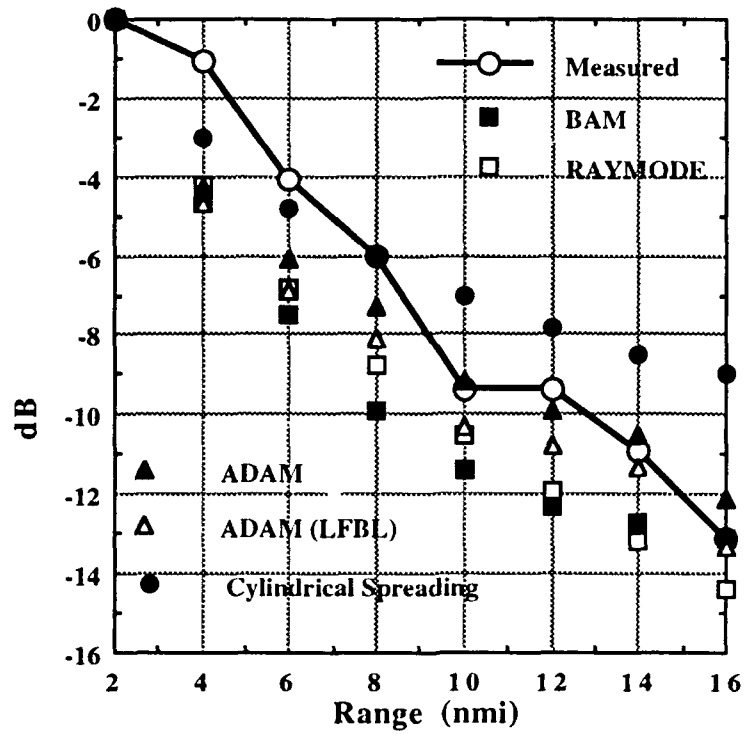


Figure 6. Plot of measured relative transmission loss versus model outputs.

Table 2. Relative transmission (dB) relative to transmission loss at 2 nmi for the data and models.

Measured	Cylindrical	Raymode	BAM	ADAM LFBL	ADAM geoacoustic
0.0	0.0	0.0	0.0	0.0	0.0
1.1	3.0	4.2	4.6	4.7	4.3
4.1	4.8	6.8	7.5	6.9	6.1
6.0	6.0	8.8	9.9	8.1	7.3
9.4	7.0	10.5	11.4	10.3	9.2
9.4	7.8	11.9	12.3	10.8	9.9
10.9	8.5	13.2	12.7	11.3	10.5
13.1	9.0	14.4	13.1	13.3	12.1
RMS error	1.9	2.3	2.5	1.5	1.2

CONCLUSIONS

For the limited relative loss data set, within the context of range independent bathymetry, each of the four models cylindrical spreading, Raymode, BAM, and ADAM performed well. Statistically there was no difference between the performance of the ADAM model using LFBL based bottom loss, and a geoacoustic based bottom loss, although the models using bottom loss followed the trend of the data better than cylindrical spreading alone.

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